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RESEARCH MEMORANDUM

for the

Air Research and Development Command, U. S. Air Force

LARGE-SCALE FLIGHT MEASUREMENTS OF ZERO-LIFT DRAG AT MACH NUMBERS FROM 0.87 TO 1.39 OF $\frac{1}{10}$-SCALE MODELS OF THE NORTHROP MX-775A MISSILE

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Langley Field, Va.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
WASHINGTON
NOV 9 1951

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SUMMARY

A flight investigation was made at high subsonic, transonic, and supersonic speeds and at high Reynolds numbers to determine the zero-lift drag of a $\frac{1}{10}$-scale model of the Northrop MX-775A missile and a $\frac{1}{10}$-scale model of the missile fuselage. The model of the complete configuration has a 45° swept wing of aspect ratio 5.5 and a 33° swept vertical fin. The body model was stabilized by three 45° swept fins.

The drag-rise Mach number for the model of the complete configuration was approximately 0.96. The drag coefficient based on total wing area was 0.0330 at Mach number 1.39. The drag coefficient of the body model less fin drag was approximately 55 percent that of the complete model at the same Mach number. Addition of the wing to the fuselage apparently resulted in a favorable drag interference near Mach number 1.0.

INTRODUCTION

At the request of the Air Research and Development Command, U. S. Air Force, the Langley Pilotless Aircraft Research Division is investigating the aerodynamic characteristics of the Northrop MX-775A missile through the use of rocket-propelled scale models. Continuous data are obtained from high subsonic to supersonic speeds at high Reynolds numbers.

This paper presents only the zero-lift drag data for a $\frac{1}{10}$-scale model of the Northrop MX-775A missile and a $\frac{1}{10}$-scale model of the

fuselage. The Mach number range for the complete configuration was 0.87 to 1.39. The range of Reynolds numbers based on the wing mean aerodynamic chord of 0.82 feet for the tests was 3.7×10^6 to 7.8×10^6.

SYMBOLS

C_D	drag coefficient (Drag/qS)
C_N	normal-force coefficient (Normal force/qS)
q	dynamic pressure, pounds per square foot
S	wing plan-form area (including area within body), 3.27 square feet
M	Mach number
R	Reynolds number based on wing mean aerodynamic chord of 0.82 feet

MODELS AND TESTS

The measured body and airfoil coordinates and the general arrangement of the two $\frac{1}{10}$-scale test models of the Northrop MX-775A missile are presented in table 1 and figure 1, respectively. Photographs of the missile are shown in figure 2 and of the model-booster combinations in figure 3. The body had a fineness ratio of 12.9 with body frontal area 5.6 percent of the wing area. The nose, cylindrical midsection, and boat tail lengths of the body were respectively, 24.05, 54.60, and 21.35 percent of the body length. The wing had an aspect ratio of 5.5, taper ratio of 0.4, and 45° sweep of the 0.4 chord line. The airfoil sections streamwise were approximately 6 percent thick and were similar to an NACA 65A006 section but were moderately drooped in the leading edge region. The vertical tail of the winged model had 33° sweep of the 0.4 chord line and streamwise airfoil sections 6.24 percent thick and similar to an NACA 63A006 section. The three 45° swept fins of the body model had hexagonal airfoil sections of 2.7 percent maximum thickness.

The models were of metal construction. The winged model was instrumented with a six-channel telemeter incorporating three pressure gages measuring free-stream total and static pressure and model base pressure. A normal accelerometer and two longitudinal accelerometers measured normal and longitudinal forces, respectively. The body model carried a four-channel telemeter, two pressure gages measuring free-stream total and static pressures, and two longitudinal accelerometers.

An ABL Deacon rocket motor was used to propel the winged model. This rocket motor delivers approximately 6200 pounds thrust for 3.2 seconds. A smaller 65-inch HVAR booster served to boost the body model.

Velocity was obtained from the CW Doppler radar. Drag was obtained directly from the longitudinal accelerometer data and by differentiation of the Doppler determined velocity-time curve. Normal force was obtained from the normal accelerometer and base-pressure force from the base-pressure and static-pressure gages of the winged model. Trajectory and atmospheric data were obtained from the space radar tracking unit and by radiosonde observations, respectively.

The variation with Mach number of Reynolds number and normal-force coefficient is presented in figures 4 and 5, respectively. The normal-force-coefficient curve shows that the model was flying very near zero lift.

The accuracy of the results is estimated to be:

Mach number	±0.010
C_D at Mach number 0.90	±0.0010
C_D at Mach number 1.39	±0.0005
C_N at Mach number 0.90	±0.015
C_N at Mach number 1.39	±0.004

RESULTS AND DISCUSSION

Drag coefficient against Mach number for the test models is presented in figure 6. For the winged model, the drag rise occurred approximately at Mach number 0.96 and rose from a value of 0.016 at Mach number 1.0 to 0.033 at Mach number 1.39. One half of this drag rise occurred between Mach numbers 1.00 and 1.05. Base drag coefficient was small over the Mach number range and varied from a maximum negative value of -0.0017 at Mach number 0.975 to a positive value of 0.0006 at Mach number 1.31. The drag of the three fins of the body model was obtained from unpublished test data of similar fins mounted as wings on a fin-stabilized body for which basic drag values were known. The drag coefficient of the body model less fin drag was approximately 55 percent that of the complete model at the same Mach number. The curve of wing plus vertical tail with interference drag was obtained by subtracting the body drag without fins from that of the complete configuration and shows that addition of the wing to the fuselage apparently resulted in a favorable drag interference near Mach number 1.0. In obtaining this curve the assumption was made that the base drag coefficient for both models was the same at the same Mach number. This assumption is believed justifiable since the base drag measured for the complete configuration constituted only a

small portion of the total drag, and any difference in the base drag coefficient of the two models due to the fins is probably within the accuracy of the data.

CONCLUSIONS

The results of flight measurements of zero-lift drag of a $\frac{1}{10}$-scale model of the Northrop MX-775A missile and a $\frac{1}{10}$-scale model of the missile body showed the following:

1. The force-break Mach number of the model of the complete missile configuration was approximately 0.96. The drag coefficients at Mach numbers 1.0 and 1.39 were 0.016 and 0.033, respectively. Base drag over the Mach number range was small.

2. The drag coefficient of the body model less fin drag was approximately 55 percent that of the complete model at the same Mach number.

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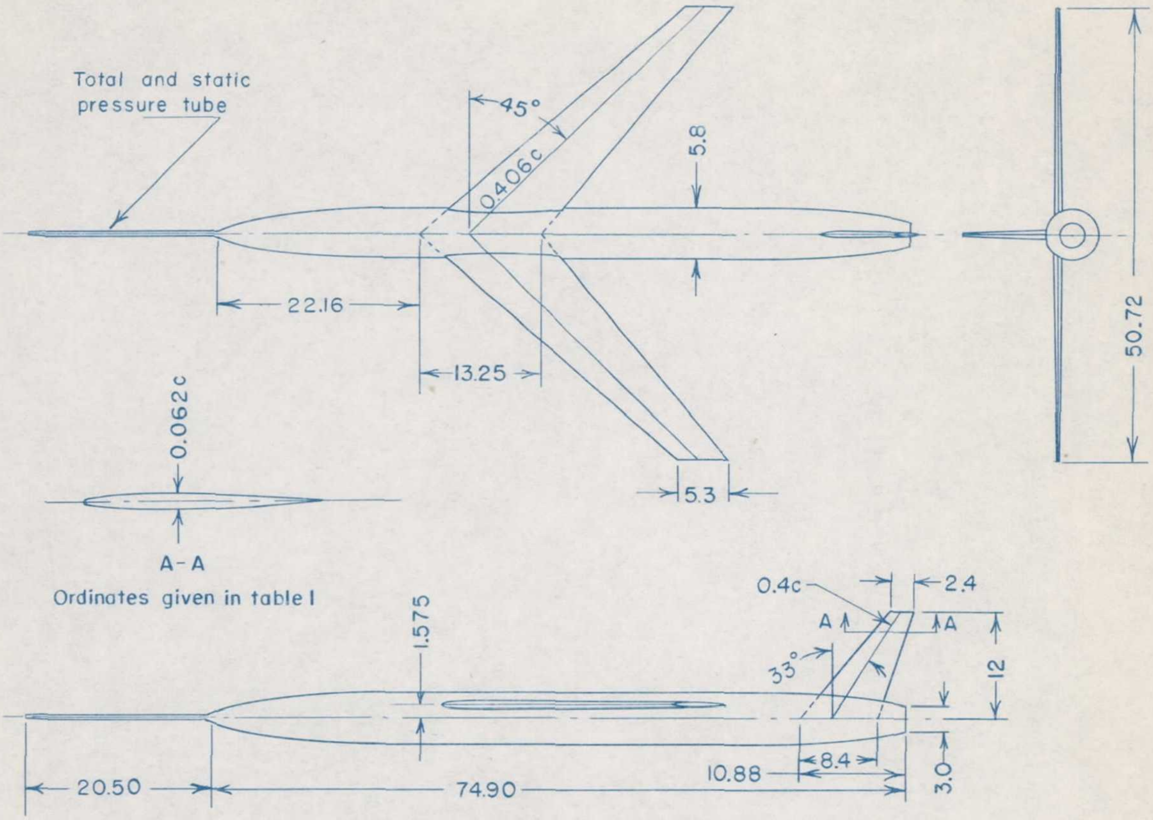
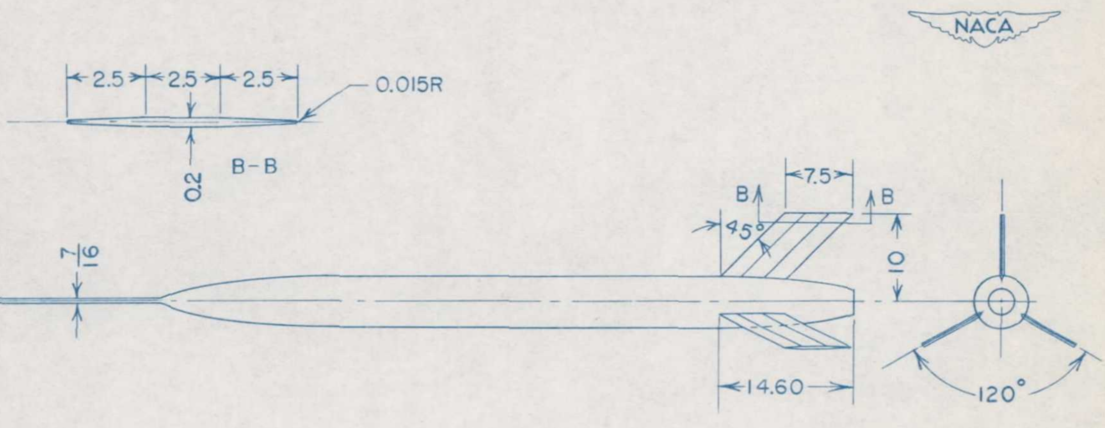
TABLE I.- BODY, WING, AND VERTICAL TAIL ORDINATES

Body Ordinates		Wing Ordinates			Vertical Tail Ordinates	
Station (in. from nose)	Radius (in)	Percent chord			Percent chord	
		Station	Upper	Lower	Station	Upper and lower
0	0	0	-0.850	0.850	0	0
.5	.610	1.25	.200	1.573	1.25	.960
1.0	.842	2.50	.610	1.855	2.50	1.335
2.0	1.140	5.00	1.120	2.190	5.00	1.770
4.0	1.565	7.50	1.480	2.410	7.50	2.060
6.0	1.930	10.00	1.773	2.567	10.00	2.265
8.0	2.235	15.00	2.227	2.782	15.00	2.567
10.0	2.485	20.00	2.532	2.922	20.00	2.770
12.0	2.680	25.00	2.747	2.998	25.00	2.907
14.0	2.810	30.00	2.900	3.033	30.00	3.010
16.0	2.885	35.00	2.980	3.040	40.00	3.120
18.0	2.900	40.00	3.010	3.020	50.00	3.057
30.0	2.900	50.00	2.855	2.860	60.00	2.810
50.0	2.900	60.00	2.380	2.380	70.00	2.395
59.0	2.900	70.00	1.812	1.812	75.00	2.090
62.0	2.875	80.00	1.233	1.233	Straight line	
64.0	2.810	90.00	.640	.640	100.00	.100
66.0	2.700	100.00	.015	.015		
68.0	2.545					
70.0	2.340					
72.0	2.070					
74.0	1.710					
74.9	1.500					

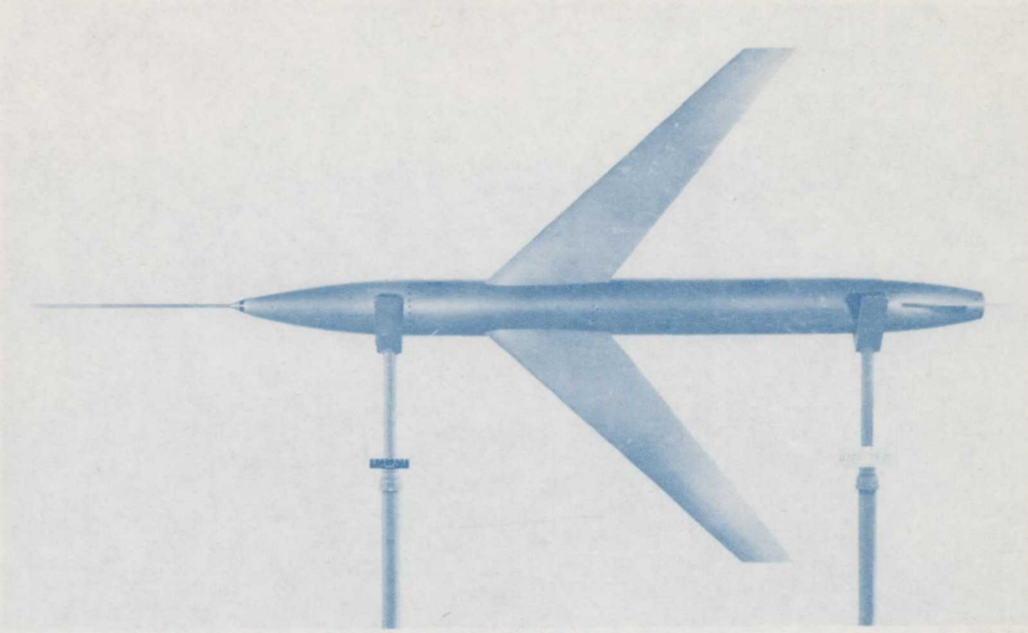


(a) Winged model.



(b) Body model.

Figure 1.- General arrangement of test models. All dimensions in inches.



(a) Top view.

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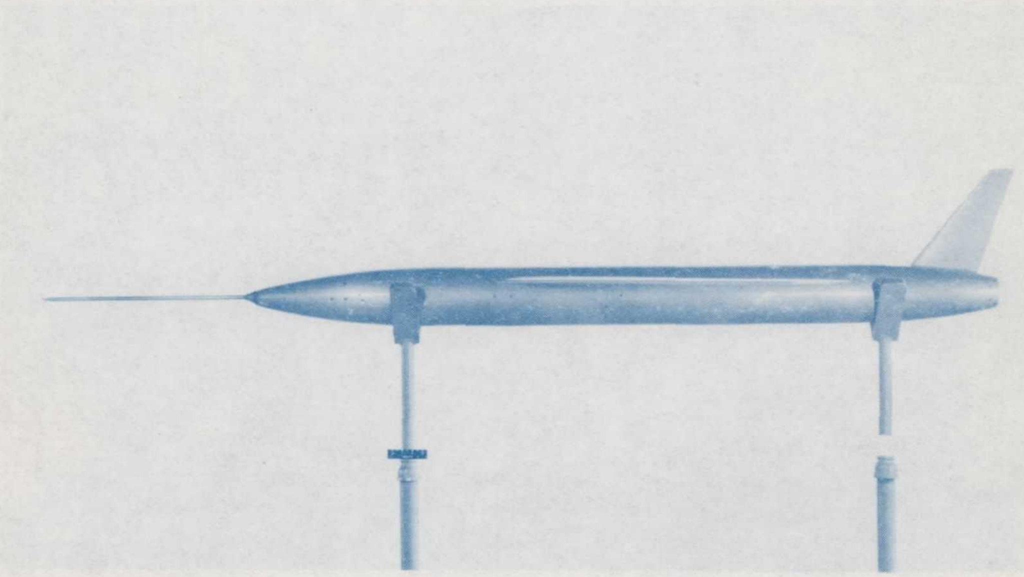

(b) Side view.

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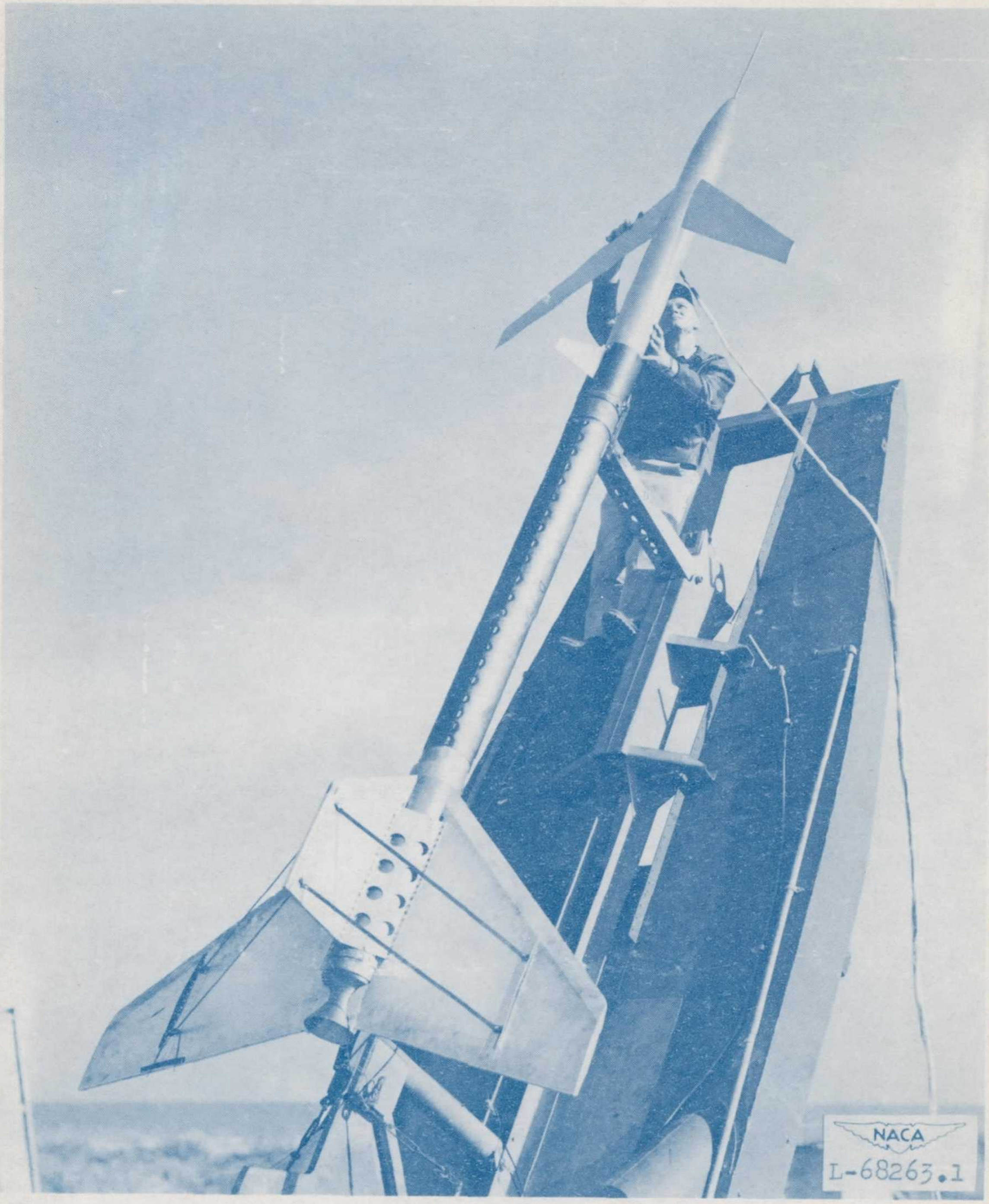
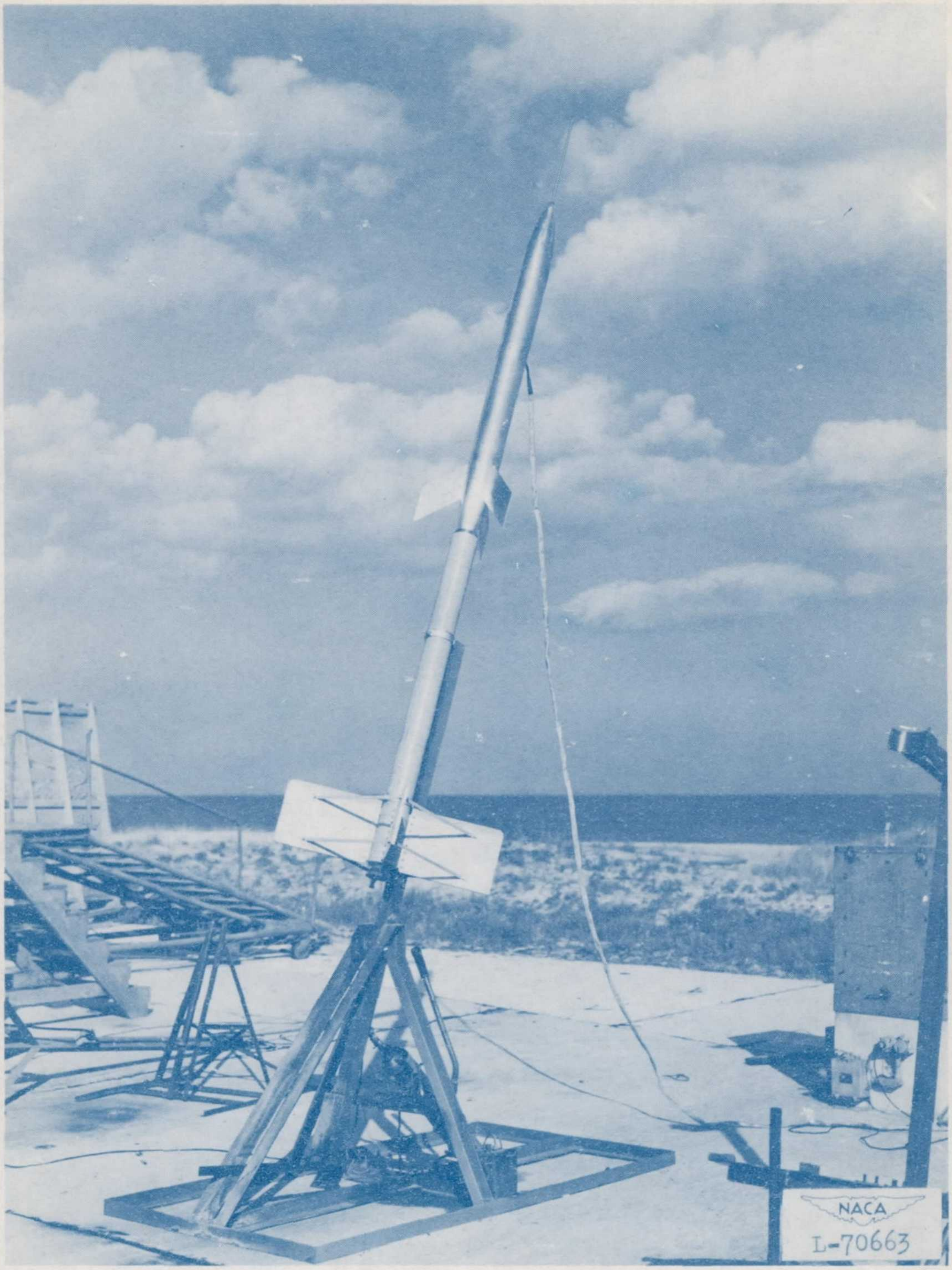
Figure 2.- Photographs of $\frac{1}{10}$ -scale model of Northrop MX-775A missile.



(a) Winged model.

Figure 3.- Model-booster combinations in launching attitude.



(b) Body model.

Figure 3.- Concluded.

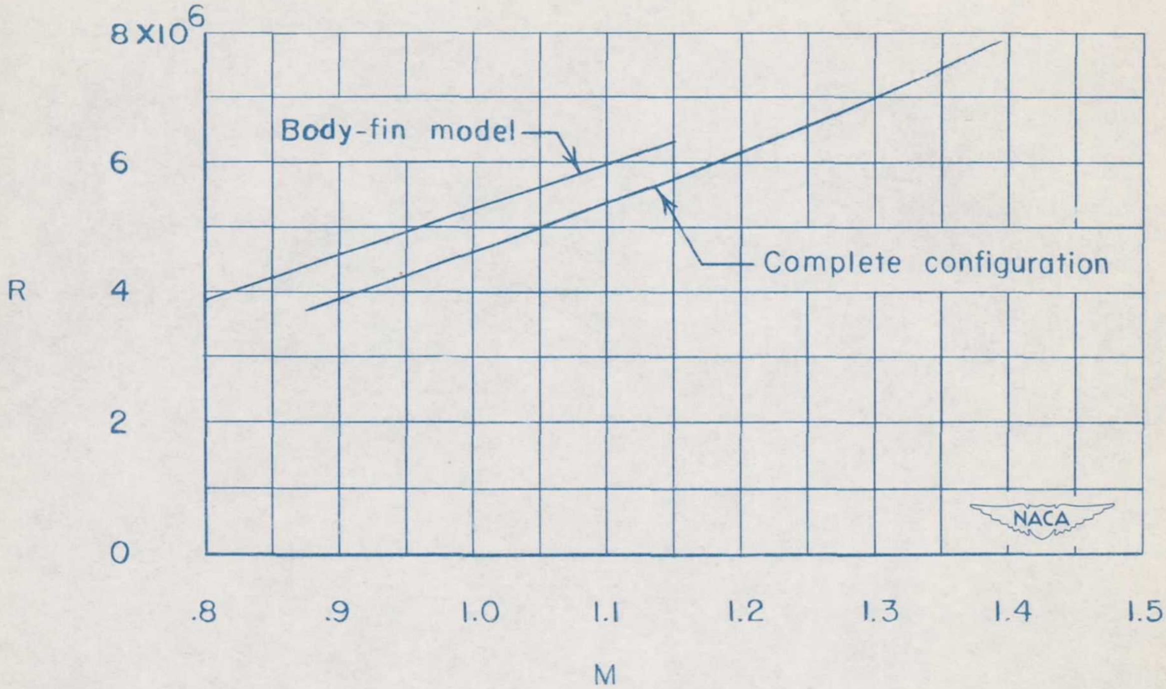


Figure 4.- Test Reynolds number based on wing mean aerodynamic chord of 0.82 feet.

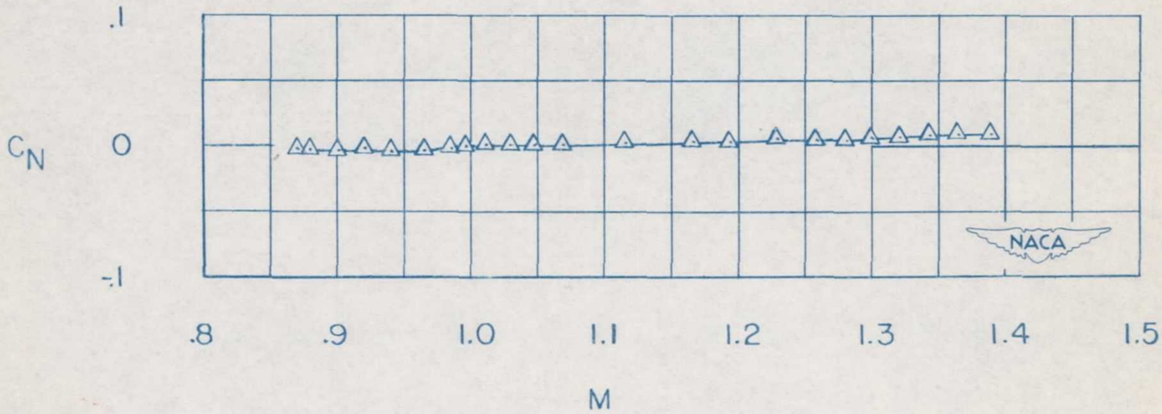
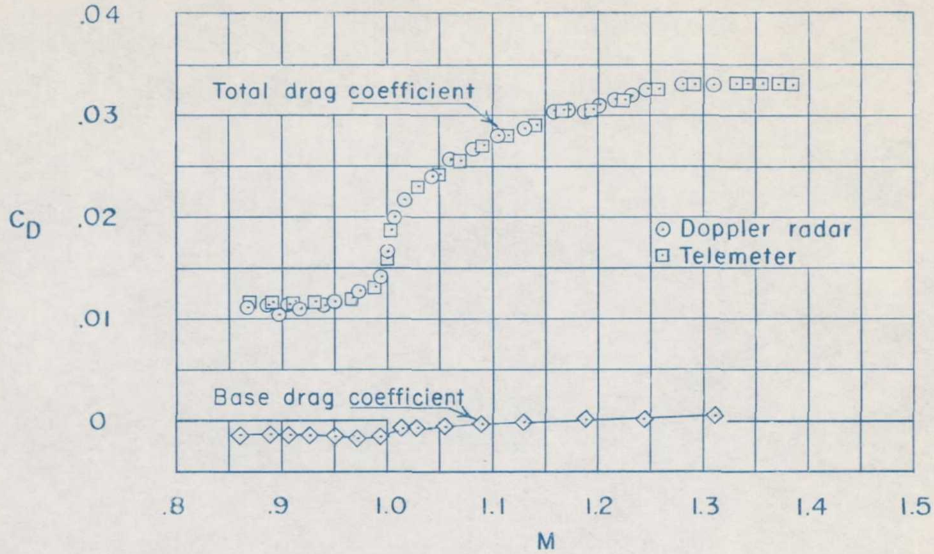
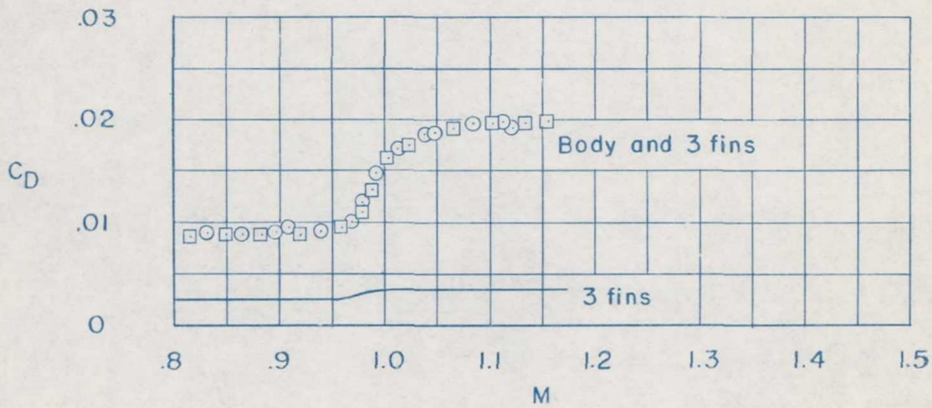


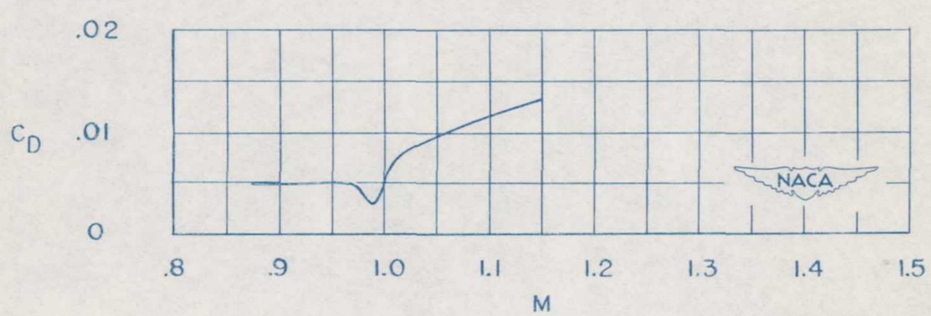
Figure 5.- Normal force coefficient for complete configuration.



(a) Complete configuration.



(b) Body-fin model.



(c) Wing and vertical tail with interference.

Figure 6.- Drag coefficient against Mach number from flight of test models.

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